FRESH AIR INTAKE FOR FIREPLACES

with funding provided by

Alberta
DEPARTMENT OF HOUSING
Innovative Housing Grants Program

FRESH AIR INTAKE FOR FIREPLACES

A Report on a Project by:

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April 1984

The views and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of the Alberta Department of Housing.

With funding provided by Alberta Department of Housing

ISBN 0-88654-044-5

FOREWORD

This study was made possible with funding provided by the Innovative Housing Grants Program of the Alberta Department of Housing. Originally conceived in 1978, the Program is intended to encourage, sponsor, and assist research and development in the fields of housing, site and subdivision design, energy conservation, site servicing and urban development. Generally, the aims of research funded by the Innovative Housing Grants Program are to reduce housing costs, increase the supply of appropriate housing or improve the utility or performance of dwelling units or subdivisions.

The main purpose of funding these studies is to examine the current issues in the field of housing and to develop innovations which offer improvements. Comments and suggestions regarding the information contained in these reports are welcome.

Innovative ideas come from a wide variety of applicants such as builders, developers, consulting firms, industry associations, municipal governments, educational institutions, non-profit groups and individuals. As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied.

Please send comments and suggestions or requests for further information to:

Innovative Housing Grants Program
Fourth Floor
10050 - 112 Street
Edmonton, Alberta
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Alberta Department of Housing
April 1984

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ACKNOWLEDGEMENTS

The interest in the project by the Alberta Department of Housing and the financial support provided is gratefully acknowledged.

Also the contribution and dicussions with Mr. Frank Cass, Mechanical Supervisor, Building Standards Branch, General Safety Service Division of Alberta Labour, provided valuable assistance in selecting materials and establishing guidelines with regards to dimensions of the various parts of the device.

INTRODUCTION

Fuel burning devices such as furnaces, wood stoves, fireplaces use air for combustion. Furnaces normally have a separate air duct to the outside for the supply of make-up and combustion air, while fireplaces and wood stoves rely on drawing air from the surrounding areas for combustion and make-up air. Combustion air is air that is required to keep the fire burning and make-up air is the air required to replace warm air that disappears through the exhaust pipe or chimney.

Because of the increased awareness of the effect of house air tightness on energy conservation, homes and other buildings are now being designed or retrofitted to increase their air tightness. This reduces air infiltration in homes and may result in an insufficient supply of combustion and make-up air to adequately operate a fireplace. Lack of adequate air supply to fireplaces may cause hazardous conditions due to lowering of the air pressure within the house. This can result in smoking of the fireplace and in extreme cases reversal of flow in exhaust systems of other appliances such as furnaces and dryer vents.

In homes where air can infiltrate around doors, windows and other discontinuities in the air seal, the fireplace can operate properly. However, this uncontrolled supply of combustion and make-up air can cause drafts and cooling of other areas of the house. Drafts are the result of cold air infiltrating into the building to replenish the air used for combustion or the warm inside air that 'goes up the chimney' in the form of make-up air.

This report proposes a design for a fresh air supply system for fireplaces to solve these problems and discusses the test results of some prototypes.

DESIGN CONSIDERATIONS

When fresh air is supplied to a fireplace a number of requirements must be satisfied. The most important ones are as follows:

1. The amount of air must be controllable.
2. The fresh air supply must be opened and closeable at the outside face of the building envelope and at the firebox.
3. The fresh air should enter the firebox at the front.

By controlling the amount of air, the oxygen supply to the fire is regulated and the rate of combustion is controlled.

By closing off the fresh air supply system at the firebox and at the point where the outside fresh air enters the duct, the fireplace will cool down at a slower rate as the locked-in air in the duct has some insulating value. If the fresh air supply system is closed off only at the firebox, condensation can occur in the duct leading to the exterior which may cause deterioration of the masonry and energy loss due to cold convection drafts.

The fresh air intake must be closeable in one operation from the inside for the sake of convenience, in particular in the winter season.

Locating the fresh air supply at the front ensures that smoke and cinders are not blown in the room when the room pressure is negative.

CODE REQUIREMENTS

Article 9.22.1.4 of the 1981 Alberta Building Code has the following requirements for combustion air:

"Combustion air for fireplaces shall be provided by an air intake other than a door or window"

ENERGY CONSIDERATIONS

The velocity of air entering the opening of a fireplace without a fresh air supply during operation has been measured to be in the order of 0.244 to 0.305 m/s (0.8 to 1.0 ft/sec.). For a common fireplace with an opening measuring 0.610 x 0.89 m (24 x 35 inches), the volume of air passing through the opening assuming an air velocity of 0.274 m/s (0.9 ft/sec.) will be:

$0.610 \times 0.889 \times 0.274 = 0.1486\ m^3/s$ (5.25 cu. ft/sec.)

If the fireplace is in operation for two hours the volume of air which will enter the fire box for combustion and make-up air requirements will be in the order of:

$0.1486 \times 60 \times 60 \times 2 = 1{,}069\ m^3$ (37784 cu. ft.)

In a conventional fireplace installation all of this air has to enter the house from the outside through windows, doors, etc. Assuming an outside temperature of - 26°C (-15°F), the energy required to increase the temperature of this air to 21°C (70°F) is approximately 1069.9 (21 + 26) x 1207 = 60,943.6 KJ (57,530 Btu). This energy is approximately equivalent of 1.64 m^3 (57.8 cu. ft) of natural gas, assuming that 1m^3 of natural gas provide 37.257mJ and that 1207J are required to increase the temperature of 1m^3 of air by one degree Celsius.

If the fireplace is equipped with a fresh air device and glass doors to minimize any draw of air from the house, the energy loss due to combustion and make-up air requirements is virtually eliminated.

DEVELOPMENT OF THE FRESH AIR INTAKE

The device is shown schematically in figures 1 through 6 on pages 10 through 15. The two main parts are identical both in design and dimension, which facilitates fabrication and minimizes the cost.

The diameter of the pipe connecting the two main elements is 127 mm (5 inches). The minimum thickness of the sheet metal to fabricate the device is 32 gauge, but for practical reasons 26 gauge is used. The shutters are fabricated from 22 gauge sheet metal in order to prevent warping when hot. A screen cover at the exterior intake will ensure that no insects enter the house through the duct.

The device is operated by lifting the interior shutter which is connected to the exterior one. A screen at the interior shutter prevents ashes from falling in the connecting duct and box. The materials used in fabricating the device are non-combustible and meet all existing code and performance requirements. The operation of the device is easy and all parts are accessible for easy maintenance or replacement should the need arise after installation.

INSTALLATION

The device can be installed during the construction of new fireplaces or retrofitted in existing masonry fireplaces, fireplaces with metal inserts or zero clearance metal fireplaces. When the device is installed in a masonry fireplace, it must be placed inside the fire box in such a way that it does not interfere with the installation and operation of glass doors. In this case the device must be inside the hearth when the doors are closed. In zero clearance fireplaces the device must be installed in such a way that it does not interfere with the main body of the fireplace.

The device can also be installed in basement fireplaces and other interior locations. This can be done by installing a connecting duct with suitable elbow connections (refer to Figure 7 on page 16 for typical installation).

When the connecting duct work is not enclosed in solid masonry, suitable insulation must be provided to prevent condensation.

For installation in new fireplaces the device is pre-assembled to the length and orientation required and then placed in position. The mason then lays the bricks around the device. This will normally not significantly increase the labour required for the construction of new fireplaces.

Retrofitting the fresh air device involves removal of the fire bricks from the floor of the fire box and removal of some exterior bricks and the creation of an opening for the connecting pipe. A total of 5 or 6 bricks will be affected on the exterior face of the fireplace.

The intake is designed in such a way that it does not require any cutting of bricks during the installation. The device is then connected and the control cable is adjusted after proper alignment. The fire bricks and exterior bricks are then rebuilt around the intakes. An experienced mason requires approximately 4 hours to complete this kind of retrofit.

Photographs 1 to 6 on pages 17 to 19 show the various stages of a retrofit installation.

EVALUATION OF THE DEVICE

One of the fresh air supply systems was installed in a house in St. Albert, Alberta. The owner observed stable temperatures in all rooms of the house when the fireplace was burning and the elimination of smoking, which used to happen before the installation of the device. During cold weather, the lighting of the fireplace no longer caused the furnace to smoke.

These observations confirm the expectations for the device.

The second fresh air supply system was installed in Edmonton. Photographs 1 to 6 on page 17 to 19 show the various aspects of the installation of the fresh air intake.

The fresh air intake device was tested as follows:

Case I: Fresh air intake device closed. Firebox open.
Case II: Fresh air intake device open. Firebox open.
Case III Fresh air intake device open. Firebox closed.

Case I

The fresh air intake device was closed with the fire box open (ie. condition of no fire box doors or doors open). The average velocity of air entering the fire box was 0.253 m/s (0.83 ft./sec.). (Appendix B)

The air was supplied from a 0.055 m^2 (85 square inch) opening in a nearby window which was intentionally left open. The velocity of the air entering at the window opening was 1.905 m/s (6.25 ft./sec.).

The total amount of air entering the fire box was calculated to be:

0.253 (m/s) x 0.474 (m^2)* = 0.112 m^3/s (3.96 cu. ft. per sec.).

The total amount of air entering the house from the open window was calculated to be:

1.905 (m/s) x 0.055 (m^2) = 0.105 m^3/s (3.71 cu. ft. per sec.).

The difference of 0.007 m^3/s (0.25 cubic feet per second) was most likely supplied by other sources such as openings around door and window frames.

Case II

When the fresh air intake was fully opened and the fire box open (ie. condition of glass doors open) the air velocity measured at the intake of the fresh air supply device was approximately 0.635 m/s (2.08 ft. per sec.).

Case III

When the fire box was closed as shown in Photo 6, on page 19, the fresh air supply device provided almost all of the combustion air. It was observed that some air was leaking into the firebox from openings between the brick, mortar joints and enclosure. The air velocity measured at the exterior intake was 2.16 m/s (7.08 ft. per sec.). The total air flow through a 100 mm (4 inch) diameter duct was calculated to be:

2.16 (m/s) x 3.14 x 0.05^2 (m^2) = 0.017 m^3/s (0.6 cu. ft. per sec.)

* size of fireplace opening:
0.584 X 0.812 m (23 X 52 inches)

It should be noted here that the amount of fresh air required to maintain the fire (combustion air) is of the order of 10 to 15% of the amount of air entering the fireplace when there are no restrictions such as glass doors. This is clearly shown from the measured quantities above (0.112 m^3 sec. and 0.017 m^3/sec.) Controlled air supply will ensure longer burning for the same amount of fuel (wood) and thus better utilization of the fireplace.

Testing Evaluation

These preliminary findings suggest that a 127 mm (5 inches) diameter connecting pipe would provide 0.027 m^3/s (0.97 cu. ft. per sec.) of fresh air to sustain the fire. Because of the small temperature difference between the outside and inside of the house at the time of testing and the relatively small height of the chimney, the air flows obtained from these tests are conservative. The installation of properly fitted glass doors, simulated in this test by placing a metal closure over the fireplace opening, will make the fresh air intake effective by increasing the air flow through the device and also by reducing the need for make-up air. It should be stated here that although the device can provide all of the combustion air and eliminate the requirement for make-up air from the house, it cannot be expected to eliminate the movement of air through the fireplace opening when no glass doors are provided. It is for this reason that the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) requires a 229 mm (9 inches) diameter air supply or equivalent to the flue area unless glass doors are provided.

Because of space limitations it is only practical to install a supply pipe of up to 127 mm (5 inches) in diameter for retrofit applications. In this case the presence of glass doors is recommended in order to ensure that the combustion air is supplied by the fresh air supply device. Even if larger diameter air supply ducts were installed in a new fireplace, glass doors are highly recommended.

CODE ASSESSMENT

As shown, in Appendix C, a letter from the Alberta Department of Labour indicates that the fresh air intake device meets the intent of the Alberta Building Code.

CONCLUSIONS

The installation of a fresh air supply system, to supply air for combustion in masonry fireplaces, will improve their energy efficiency. The device developed performed satisfactorily. Two important features are the control of the air supply and the double closure of the fresh air intake device.

FUTURE PLANS

The unit will be manufactured for distribution in Alberta and the rest of Canada. The cost of the device is less than $100.00 (Canadian) installed for new fireplaces and $250.00 to $300.00 for a retrofit installations.

Patent applications are pending in Canada and the U.S.A.

APPENDIX A

DESIGN DETAILS

AND

PHOTOGRAPHS

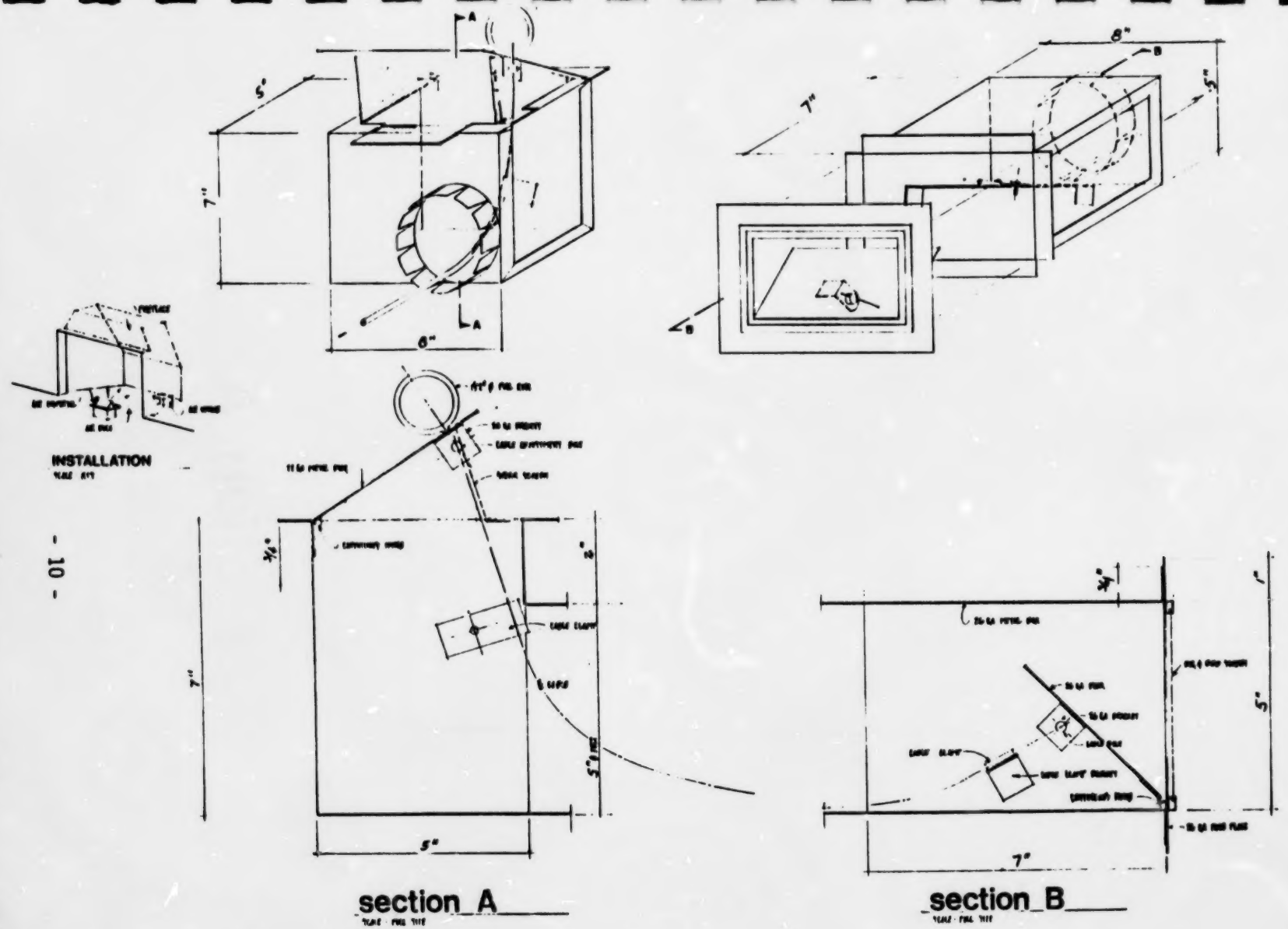
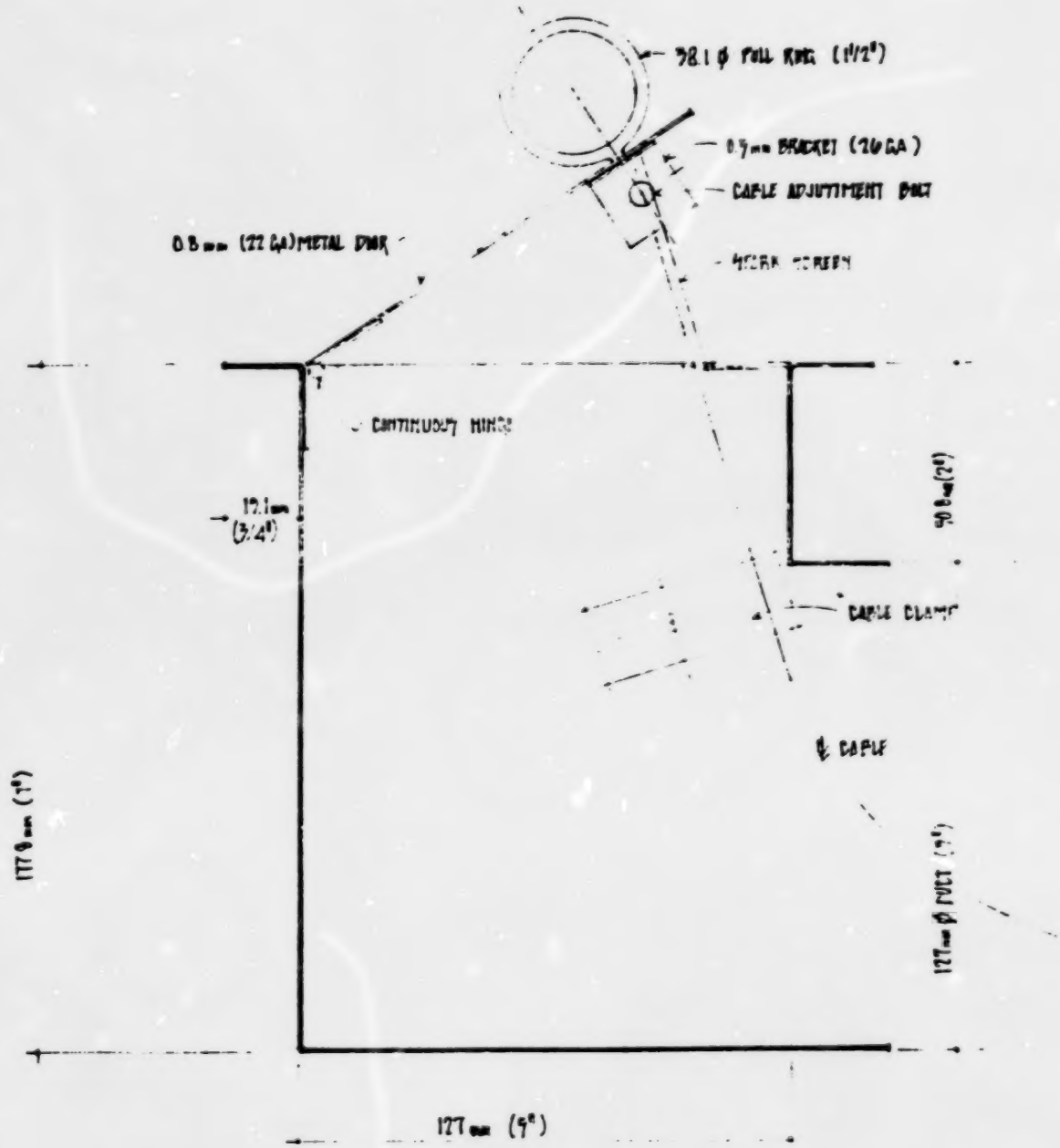


Fig. 1 - Main Elements of Fresh Air Intake



section A

SCALE FULL SIZE

Fig. 2 - View of Interior Box with Spark Screen.

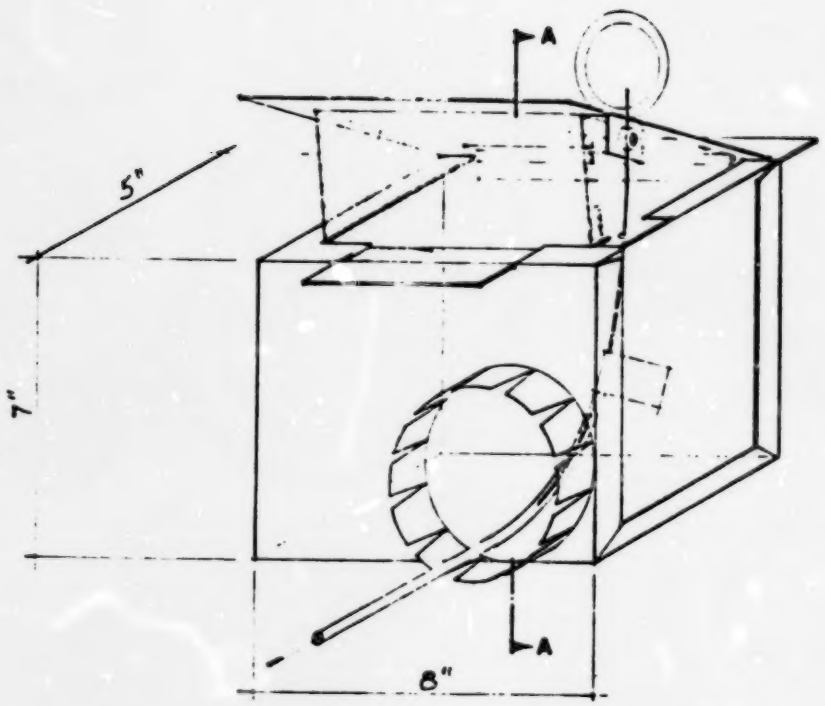
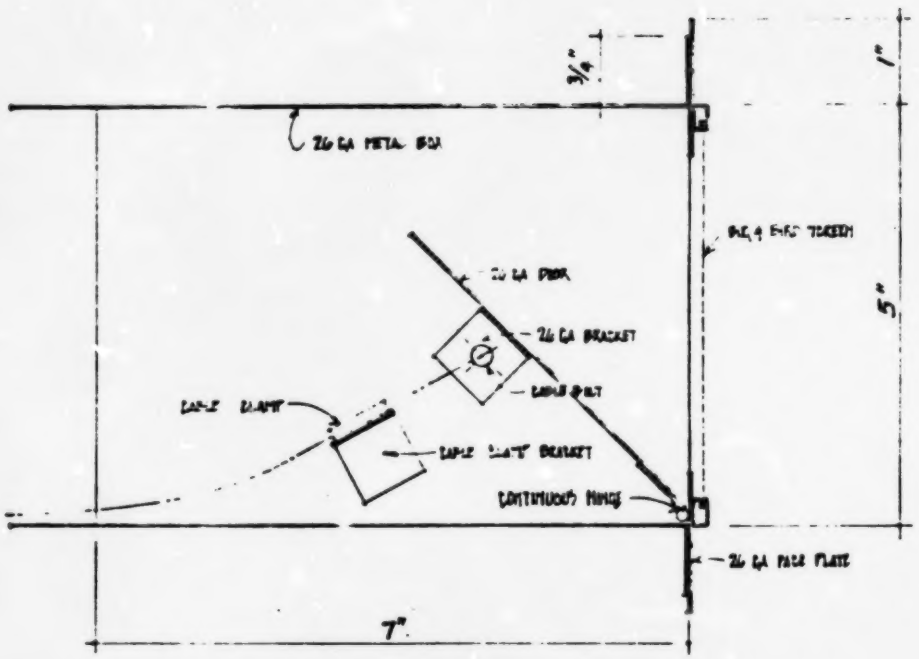


Fig. 3 - ISOMETRIC OF INTERIOR BOX



section B

Fig. 4 - VIEW OF EXTERIOR BOX SHOWING DOOR AND ACCESSORIES.

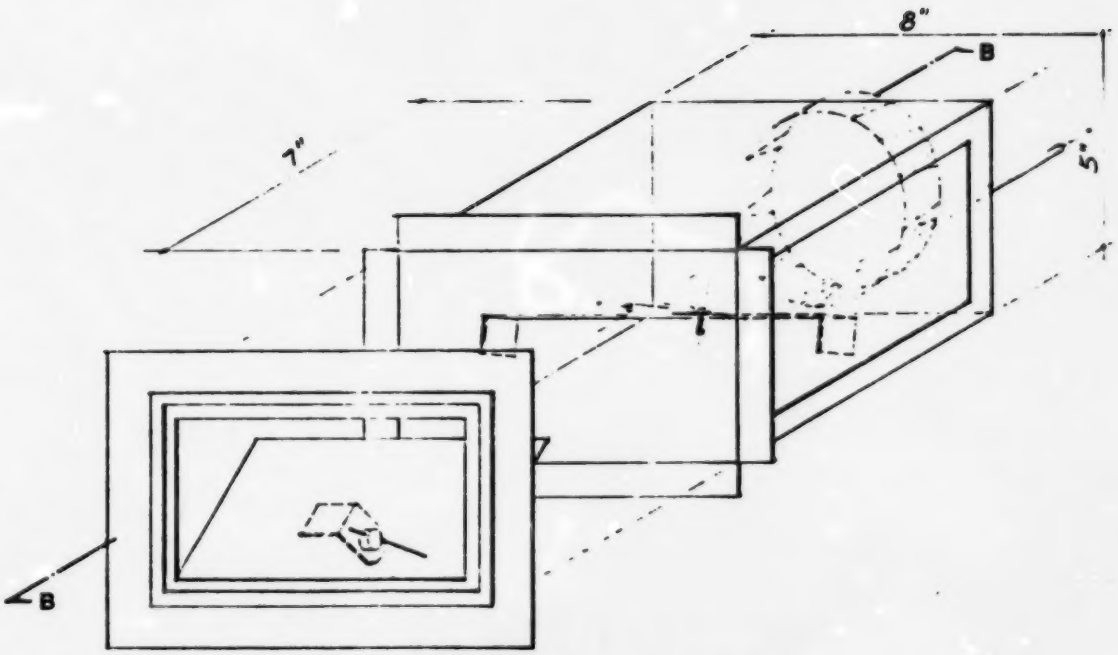
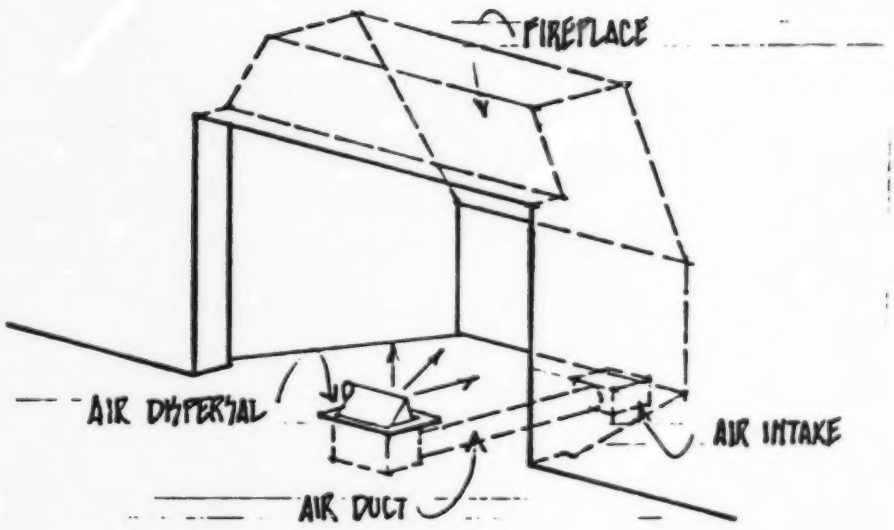


Fig. 5 - ISOMETRIC OF EXTERIOR BOX



INSTALLATION

SCALE - NTS

Fig. 6 - INSTALLATION OF DEVICE SHOWING POSITION OF CONNECTING DUCT.

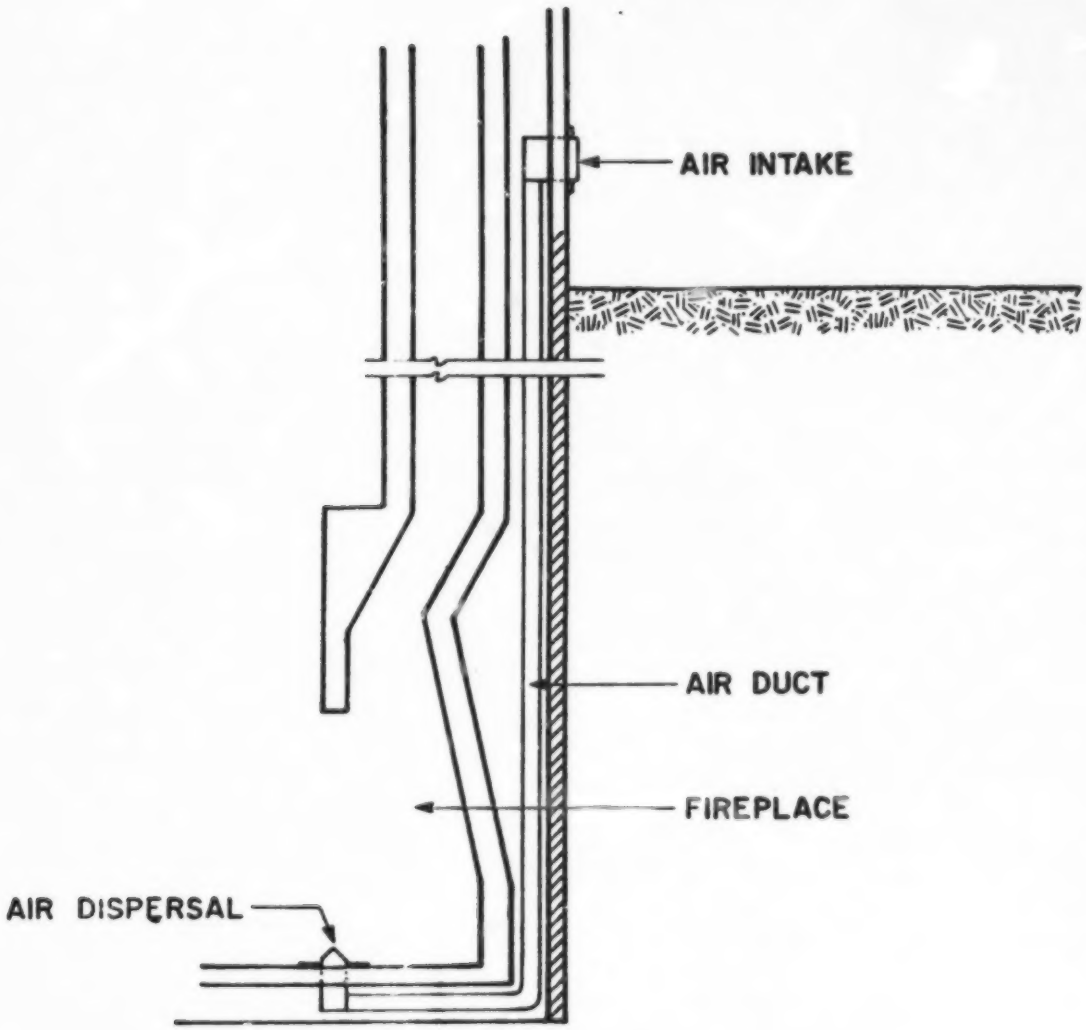


Fig.7 BASEMENT INSTALLATION

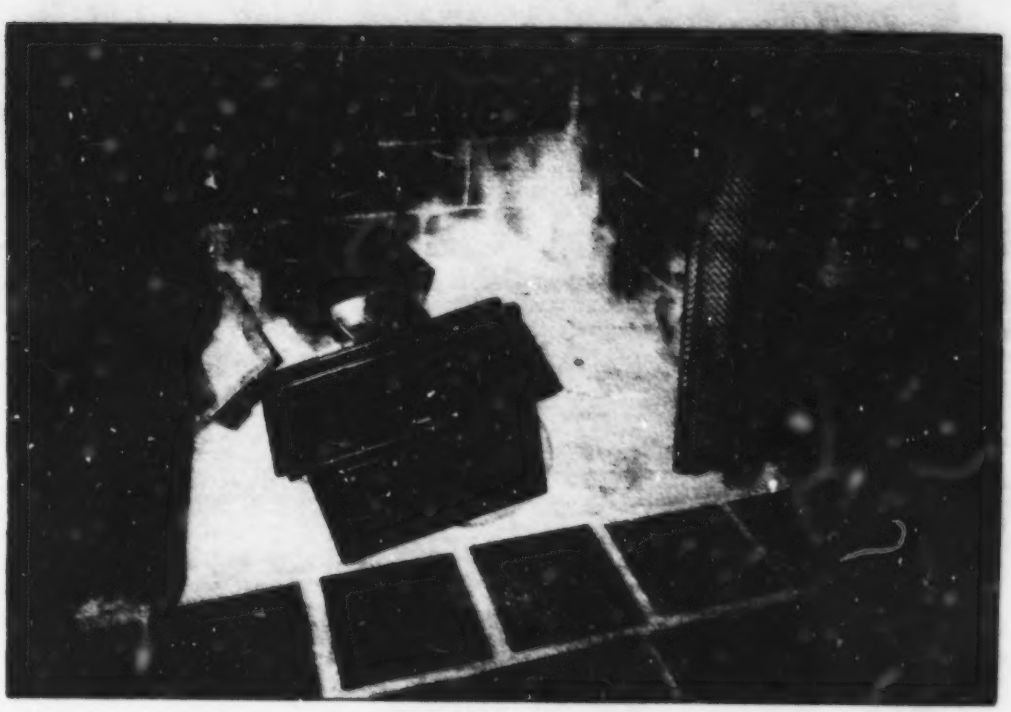


Photo 1 - Main Elements of the Fresh Air Intake.

Photo 2 - Interior Outlet Partially Installed.

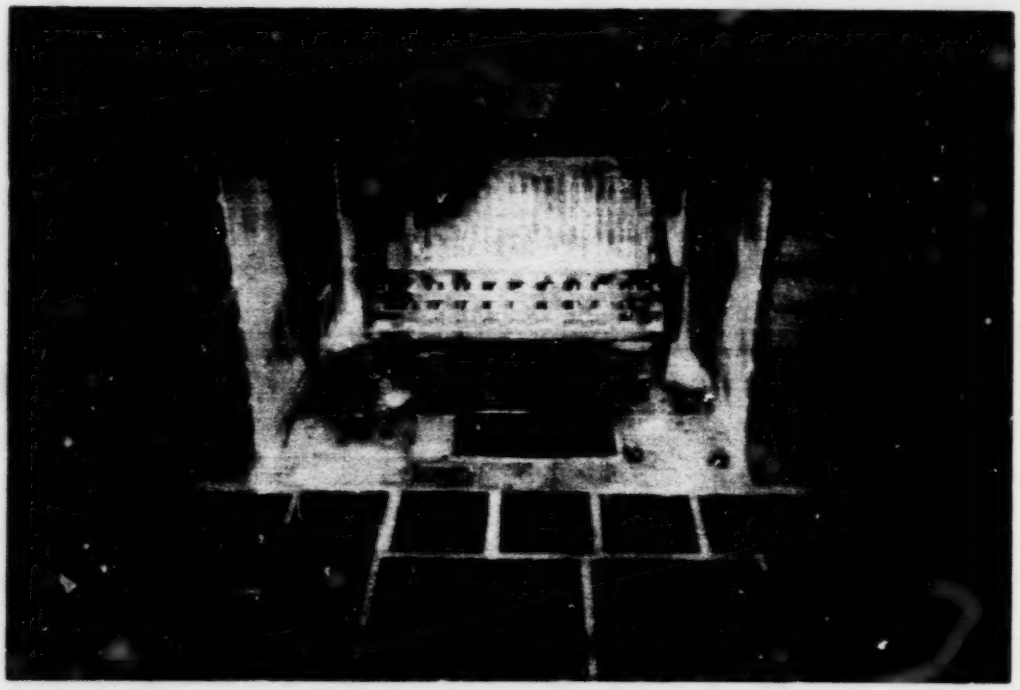


Photo 3 - Finished Interior Installation.

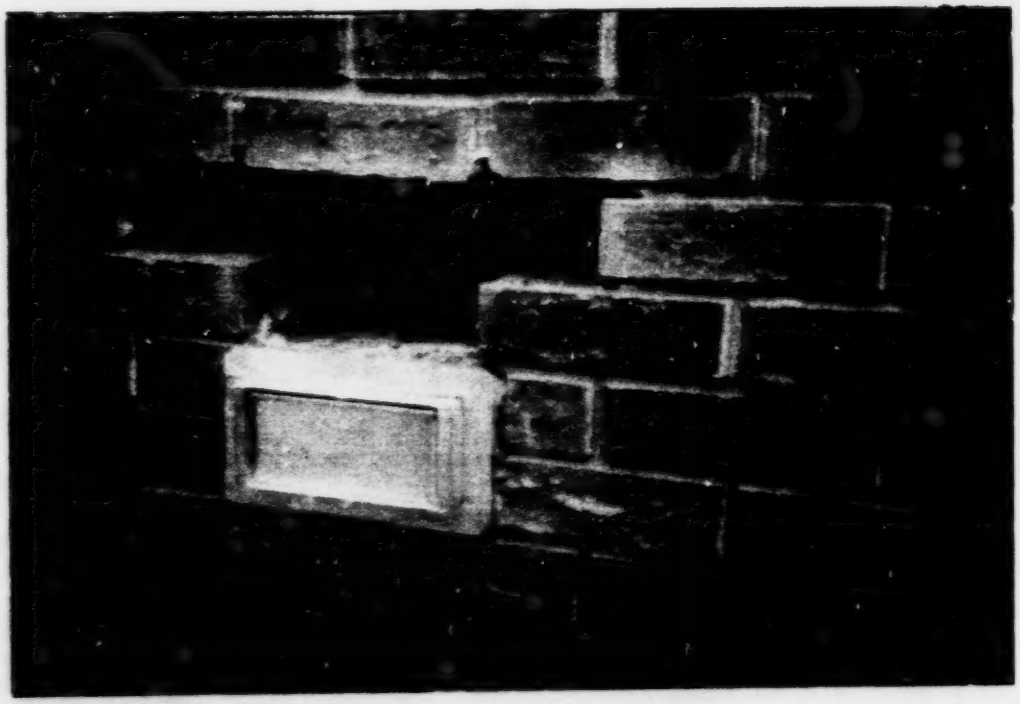


Photo 4 - Exterior Intake Partially Installed.

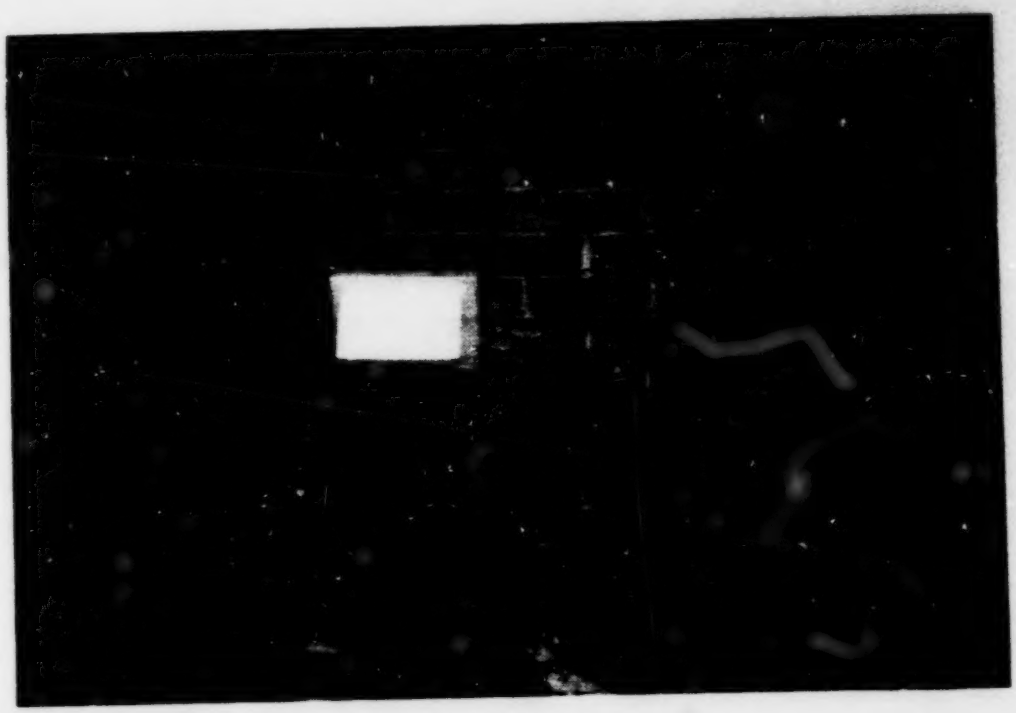


Photo 5 - Finished Exterior Installed.

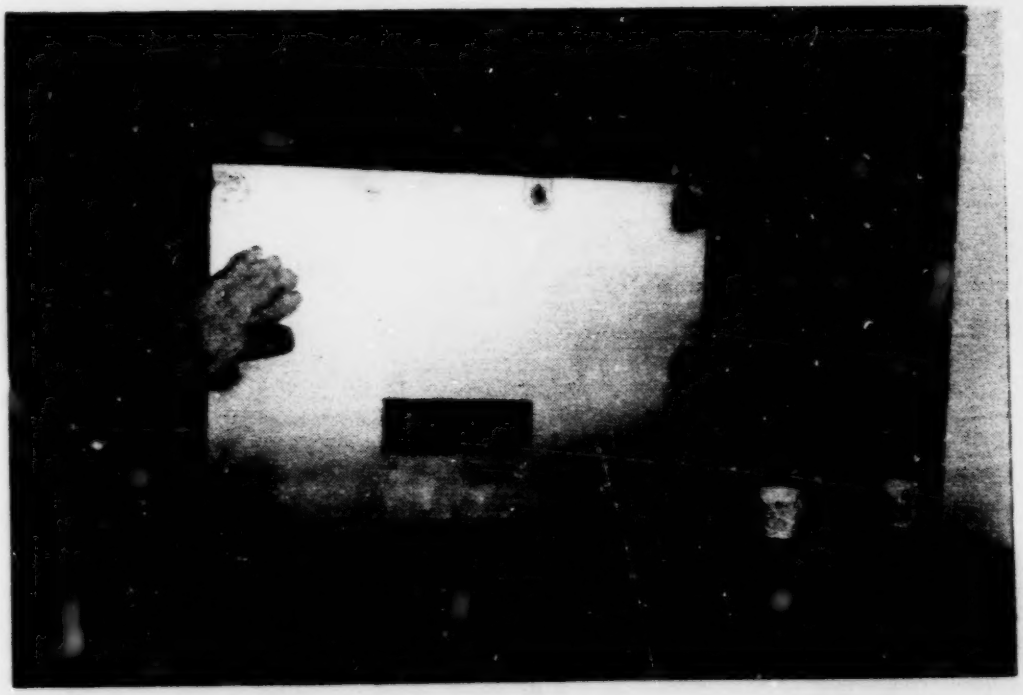


Photo 6 - Metal Closure Provided for Testing.

APPENDIX B

TEST RESULTS

TEST RESULTS

Sheet 1 of 2

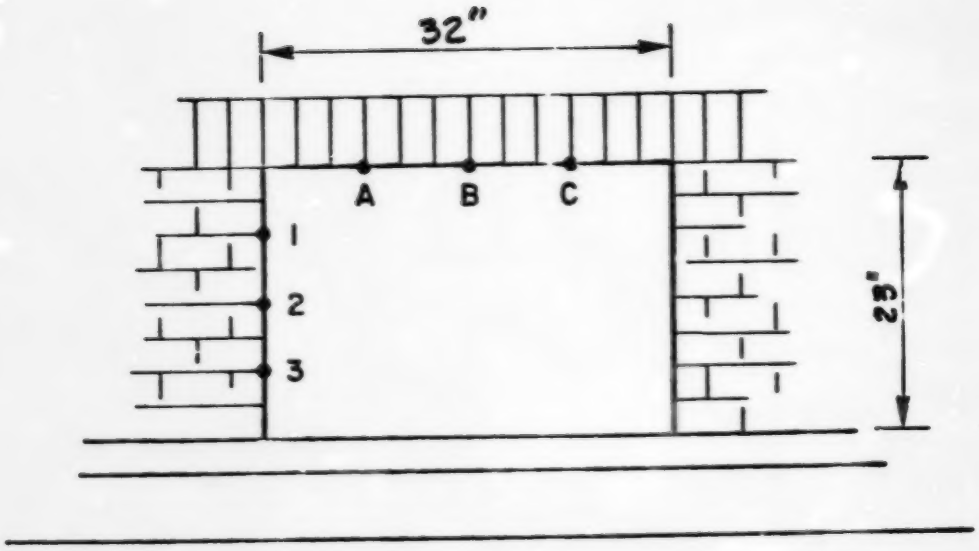


Fig. 8 Locations of Air Flow Measurement

TEST RESULTS

Sheet 2 of 2

TABLE 1 AIRFLOW MEASUREMENTS

Location	Device closed ft/min.	Device open ft/min.	Comments
1	50	50	an overall
2	50	50	opening of
3	50	50	85 $in.^2$ was
A	50	60	provided at
B	50	55	one window.
C	55	55	

See Figure 8 - for locations of points where flow was measured.

APPENDIX C

CODE ASSESSMENT

Alberta
LABOUR
General Safety Services Division
Building Standards Branch

201, 10339 - 124 Street, Edmonton, Alberta, Canada T5N 3W1 403/427-6461

1984 05 08

Dr. M.A. Hatzinikolas, P. Eng.
Alberta Masonry Institute
Suite 200, 10712 - 176 Street
Edmonton, Alberta
T5S 1G7

Dear Sir:

RE: Fresh Air Intake For Fireplaces

The Combair fresh air intake when used in combination with glass doors would meet the intent of the Alberta Building Code.

The installation instructions are written with masonry fireplaces in mind and therefore further information would be desirable if the unit is to be marketed for factory built fireplaces as well, since the unit would not be permitted to be installed within the firebox of a factory built unit. Rather it would be installed on the edge or sides of the hearth extension.

Many persons have been looking for this type of equipment and we are glad to see that is is now on the market.

Yours truly

F. Cass, P. Eng.
Mechanical Supervisor

FC/ig

cc. - Mr. W. Cool, P. Eng.
Research Project Manager
Alberta Housing
- J.M. Weinberger
Regional Administrator
- P. Mousseau, MRAIC
Supervisor, Research and Approvals